Shipman & Skelley

Design of an Auxiliary Gas Producer Power Plant For the Univ. of Ill.

Mech. Engineering

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DESIGN OF AN AUXILIARY GAS PRODUCER POWER PLANT FOR THE UNIVERSITY OF ILLINOIS

BY

ANDREW BRADT SHIPMAN
AND
CHARLES EDWARD SKELLEY

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN MECHANICAL ENGINEERING

IN THE
COLLEGE OF ENGINEERING
OF THE
UNIVERSITY OF ILLINOIS
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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

ANDREW BRADT SHIPMAN and CHARLES EDWARD SKELLY

ENTITLED DESIGN OF AN AUXILIARY GAS PRODUCER POWER PLANT

FOR THE UNIVERSITY OF ILLINOIS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering

L. P. Breckenridge

HEAD OF DEPARTMENT OF Mechanical Engineering

DESIGN OF AN AUXILIARY GAS PRODUCER POWER PLANT FOR THE UNIVERSITY OF ILLINOIS.

INTRODUCTION.

As the title states, the object of this work is the Design of an Auxiliary Gas Producer Power Plant for the University of Illinois.

This plant is to operate as an auxiliary to the steam power plant and is designed to furnish power during the summer or at any other time that the regular plant is shut down, or when more power is needed than can be furnished by the regular plant.

Since the plant depends entirely upon producer gas for its power, it is thought wise to give such explanations as will make clear the theory of producer gas and the mechanical construction of the producer apparatus and its operation.

Desirable sites for the plant were carefully looked over and their advantages and dis-advantages discussed.

The design of the plant is largely given by the drawings, but all calculations and assumptions, which were used in determining sizes of engines, producers. purifiers, etc. are carefully given.

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I.

THEORY OF PRODUCER GAS.

Producer gas is obtained by the incomplete combustion of fuel in the producer. If plenty of air is admitted to the producer, the fuel is completely burned to CO_2 and ash. However, by limiting the supply of air the fuel is burned to CO which is a combustible gas. This chemical reaction is brought about in the following way:

The fuel in the bottom of the producer is completely burned to CO_2. This gas imparts its heat to the fuel above bringing that fuel to an incandescent state. The CO_2 coming in contact with the glowing fuel, takes up another atom of carbon.

$$CO_2 + C + \text{heat} = 2CO.$$

It is found that the minimum amount of CO_2 is formed when the incandescent fuel is at a temperature of about 1900° F.

In order to increase the calorific value of the gas and also to utilize the surplus heat of combination, that tends to raise the temperature above the economical point of 1900° F., it is now common practice to add a certain amount of moisture in the form of steam. This steam on entering the zone of high temperature is dissociated into 2 H and O. The oxygen (O) combines with carbon (C) to form CO and the hydrogen (H) goes into the gas as free hydrogen. The equation

$$H_2O + C + \text{heat} = 2H + CO.$$

represents what takes place. As hydrogen has the very high heat value of 62000 B.T.U. per pound, it greatly enriches the gas.

The moisture not only increases the value of the gas, but where clinkering coals are used it helps greatly in breaking up the clinker. However, it is just as essential not to add too much steam as to add too little, for an excess rapidly cools the fire below the economical temperature of 1900° F.

II.

LOCATION.

The site for the plant was chosen with these three ideas in view:

1. It should lie along a railroad, so as to do away with the hauling of coal.

2. It should lie near the University.

3. It should be large enough to allow for extension of building in the future.

There are about three available sites fulfilling these conditions.

(a) A plot lying north of and along the C.C.C. & St.L. R.R. tracks between Romine and Wright Streets.

(b) A plot similarly situated just south of and along the Wabash tracks.

(c) A plot situated along the east side of the Illinois Central tracks, directly west of the Agriculture Building.

The first site mentioned is the most favorable of the three. It is sufficiently large. There are no buildings nor trees nor shrubbery on it. It can be easily drained. It is distant about one half mile directly north of the present plant.

The second site has similar advantages with the exception that it is occupied by three small houses which would have to be torn down or moved off. There are also a number of trees and some shrubbery that would have to be cleared out. The land, however, is higher and would require no draining.

The third site is about a mile from the present plant and has the further disadvantage of being low.

Any one of these sites could be used for this plant, but the first mentioned site, along the Big Four is undoubtedly the best of the three and we have, accordingly, decided to locate the plant there.

III.

CAPACITY OF PLANT.

The capacity of the plant without overload is to be 525 kilowatts at the switchboard. In making calculations to obtain this horsepower it was necessary to assume that a direct connected engine and generator had a mechanical efficiency of 85%, which is about the efficiency allowed for a first class unit. It is evident from this that at least 700 I.H.P. in engines will be required.

To supply these engines three producers will be needed. Two of the producers should be capable of furnishing enough gas to supply two 200 H.P. engines and the third producer of supplying the remaining 300 H.P. of engines. Two No. 7's and one No. 8 R. D. Wood producers, having a total capacity of about 800 H.P. would be large enough to run the engines, when they were working under a maximum load. In case the load is light one or two of the producers and engines can be easily cut out.

IV.

TYPES OF PRODUCERS.

There are two general tupes of producers on the market at present:

1. The Suction Gas Producer.
2. The Pressure Gas Producer.

(1) The suction gas producer depends upon the gas engine, with which it is connected for its operation. The stroke of the engine makes a partial vacuum in the cylinder and the charge of gas rushes into this vacuum. Gas to take the place of what has gone into the engine is sucked from the producer at the same time and a draft of air is created up through the producer. This air furnishes the required amount of oxygen to the burning fuel. Thus the suction producer operates automatically to supply gas as it is used by the engine. However the great drawback to this style of producer is that it can only gasify such fuels as yield a very clean gas. This arises from the fact that but a small amount of purifying apparatus can be used, as the drag on the engine is too great where the gas has to be sucked through much purifying apparatus. The suction producer is therefore out of the question for this plant where Illinois coal, that gives a very impure gas, must be burned.

(2) The other type, the pressure gas producer, can,however, gasify bituminous coal. It does not depend upon the engine for its draft, as this is supplied by a fan or jet blower powerful enough to force a blast through the producer and the necessary pu-

rification apparatus. The gas does not enter the engine directly after leaving the purifiers but is turned into a gas holder under pressure. This gas holder serves the purpose of a storage tank, and it also keeps the gas under a constant pressure. The engine receives its supply from the holder.

V.

PRODUCER SELECTED FOR PLANT.

(a) REASONS FOR CHOICE OF PRODUCER.- After having decided that, under the conditions, the pressure gas producer was the type that was needed, it was necessary to select the particular make of pressure producer which would satisfy the requirements of this plant. It was rather forcibly impressed upon the designers at this point that the gas producer is still largely in the experimental stage, and that the makers themselves are not very certain what their producers can do in actual practice.

While it is not the object of this work to advertise any particular type of producer, yet it was decided after looking over many makes of producers, that the one manufactured by R. D. Wood & Co. of Philadelphia, Penn. is the best suited for this plant. This make was selected mainly for the several reasons as follows: (a) Automatic Feed Device, (b) Revolving Ash Table, (c) Good Purification System, (d) Good Performance in Actual Use and in Tests.

The Automatic Feed, the Revolving Ash Table and Purification System will be described later. The last reason for this choice will be discussed somewhat at length as it is the most important and the only reliable means at the disposal of the writers for gaining any accurate information of the performance of the producer.

The first test which will be briefly described was made in 1899 on the 400 H.P. Erie Railroad plant at Jersey City, N.J. This plant consisted of two No. 7 producers which were of suffici-

ent capacity to operate about 400 H.P. in Otto Gas Engines. The calorific value of the gas generated was 136 to 143 B.T.U. per cubic foot, and each pound of coal produced about 85 cubic feet of gas. The fuel which was a rice anthracite thus had a heat value of 12000 B.T.U. per pound. The engines gave an indicated horse power on 1.03 pounds of coal. This is a rather remarkable performance, but with the improvements of the last five years, this producer should guarantee a horse power hour per 1-1/4 pounds good grade hard coal.

The test, however, which is of the greatest value was conducted by R. H. Fernald at the St. Louis Exposition. The producer used was a No. 7 R. D. Wood & Co. make, of about 250 H.P. The engine which used the gas was a three cylinder, vertical, Westinghouse gas engine rated at 235 B.H.P. This engine was belt connected to a 175 K.W. direct current generator. The energy was dissipated by water rheostats. The tests with a few exceptions were of 30 hours duration. The tests were made to determine the possibility of using bituminous coals in a producer and not to show how efficiently the producer would burn bituminous coal. The results showed conclusively that soft coals can be burned without difficulty and also that the producer works very efficiently on soft coals.

The two Illinois coals tested gasified readily and gave no trouble with clinker. By glancing at the accompanying table, it will be seen that one of these coals gave a B.H.P. per hour on 1.49 lbs. of coal and the other on 1.50 lbs. This shows clearly that the producer can gasify Illinois coals with a high degree of economy.

Brief summary of producer-gas tests of eighteen bituminous coals and lignites.

TESTS			Name of sample	COAL PER HOUR, POUNDS						BRITISH THERMAL UNITS							[illegible]						ECONOMIC RESULTS. Pounds of coal consumed in producer per horsepower per hour												ECONOMIC RESULTS. Equivalent pounds of coal used by producer plant per horsepower per hour												AVERAGE COMPOSITION OF GAS BY VOLUME PER CENT						Name of sample	No. of test
				Consumed in producer			Equivalent used by producer plant			Per pound			Per cubic foot of standard gas	[illegible]	[illegible]	[illegible]	[illegible]			Per pound equivalent used by producer plant			Per electrical horsepower available for outside purposes			Per electrical horsepower developed at switchboard			Per brake horsepower available for outside purposes			Per brake horsepower developed at engine			Per electrical horsepower available for outside purposes			Per electrical horsepower developed at switchboard			Per brake horsepower available for outside purposes			Per brake horsepower developed at engine										
No. of test	Date of test	Duration in hours		Coal as fired	Dry coal	Combustible	Coal as fired	Dry coal	Combustible	Coal as fired	Dry coal	Combustible					Coal as fired	Dry coal	Combustible	Coal as fired	Dry coal	Combustible	Coal as fired	Dry coal	Combustible	Coal as fired	Dry coal	Combustible	Coal as fired	Dry coal	Combustible	Coal as fired	Dry coal	Combustible	Coal as fired	Dry coal	Combustible	Coal as fired	Dry coal	Combustible	Coal as fired	Dry coal	Combustible	Coal as fired	Dry coal	Combustible	Carbon dioxide (CO_2)	Oxygen (O)	Carbon monoxide (CO)	Hydrogen (H)	Marsh gas (CH_4)	Nitrogen (N)		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	4	1
2	Oct. 10-11	13.00	Alabama No. 2	310.5	290.0	280.0	311.1	[illegible]	300.8	12,865	[illegible]	14,820	149.2	9,000	11,420	18,090	[illegible]	62.4	64.5	52.9	55.0	58.9	1.61	1.55	1.45	1.55	1.49	1.40	1.37	1.32	1.23	1.42	1.27	1.19	1.77	[illegible]	[illegible]	[illegible]	1.61	[illegible]	1.51	1.45	[illegible]	1.16	1.10	1.00	8.10	10	10.65	[illegible]	5.61	[illegible]	Alabama No. 2	2
15	Dec. 13-14	30.00	Colorado No. 1	361.4	290.7	260.3	428.1	[illegible]	316.0	9,707	[illegible]	13,210	140.0	[illegible]	9,700	15,343	42	52.8	57.0	35.8	44.0	48.5	1.95	1.56	1.15	1.82	1.47	1.35	1.66	1.32	1.23	1.55	1.23	1.14	2.30	[illegible]	[illegible]	[illegible]	1.71	1.58	1.96	1.66	1.11	1.87	[illegible]	1.74	10.11	[illegible]	[illegible]	11.05	[illegible]	[illegible]	Colorado No. 1	15
a6	Oct. 31-Nov. 1	30.00	Illinois No. 3	350.0	323.3	280.3	380.0	[illegible]	340.2	12,010	[illegible]	14,560	154.8	8,530	11,060	17,112	49.8	[illegible]	60.2	45.1	48.8	51.5	1.82	1.68	1.50	1.75	1.62	1.45	1.54	1.43	1.28	1.49	[illegible]	1.23	2.01	[illegible]	1.66	[illegible]	[illegible]	1.60	1.70	[illegible]	1.41	1.64	[illegible]	1.46	10.53	[illegible]	[illegible]	8.45	1.00	[illegible]	Illinois No. 3	a6
a9	Nov. 10-11	30.00	Illinois No. 4	350.0	300.3	271.1	308.2	348.5	311.0	11,237	12,811	14,344	[illegible]	8,810	11,020	17,881	[illegible]	[illegible]	65.3	44.9	51.1	57.4	1.85	1.62	1.45	1.76	1.55	1.38	1.57	1.37	1.23	1.50	1.31	1.17	2.11	1.84	1.66	2.01	[illegible]	[illegible]	1.70	[illegible]	1.10	1.71	1.60	1.44	9.72	12	15.12	9.98	0.00	[illegible]	Illinois No. 4	a9
a14	Dec. 2-3	29.07	Indiana No. 1	401.5	310.3	300.5	433.0	381.8	341.0	[illegible]	13,037	14,720	[illegible]	[illegible]	[illegible]	17,500	44.5	40.3	56.7	40.4	45.6	51.5	2.10	1.86	1.64	1.97	1.75	1.55	1.78	1.58	1.40	1.68	1.49	[illegible]	2.31	2.04	1.81	2.17	[illegible]	1.71	1.90	1.74	1.54	1.85	1.64	1.47	[illegible]	[illegible]	11.10	[illegible]	[illegible]	[illegible]	Indiana No. 1	a14
a13	Nov. 28-29	7.00	Indiana No. 2	300.0	271.0	244.8	338.0	312.0	278.8	11,822	12,053	[illegible]	[illegible]	10,140	11,750	17,450	58.2	63.6	71.3	51.6	55.9	62.6	1.57	1.43	1.28	1.40	1.30	1.22	1.33	1.22	1.09	1.27	1.10	1.03	[illegible]	1.61	1.40	[illegible]	.85	1.30	1.52	1.30	[illegible]	1.43	[illegible]	1.18	11.80	[illegible]	11.40	10.00	[illegible]	[illegible]	Indiana No. 2	a13
1	Oct. 3-4	31.00	Indian Territory No. 1	361.0	344.0	312.0	[illegible]	374.0	339.3	[illegible]	13,455	13,800	150.2	8,020	12,350	[illegible]	51.6	54.1	59.4	47.4	40.9	51.6	1.84	.78	1.59	1.77	1.69	1.53	1.57	1.50	1.30	1.50	[illegible]	1.30	2.00	1.91	1.71	[illegible]	1.83	1.60	[illegible]	[illegible]	[illegible]	1.64	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	4.09	[illegible]	Indian Territory No. 1	1
a12	Nov. 25-26	30.00	Kentucky No. 1	370.0	343.3	310.0	410.8	[illegible]	344.2	12,283	[illegible]	14,050	150.9	8,610	12,500	[illegible]	51.2	55.1	61.1	46.2	49.7	55.0	1.95	1.81	1.63	1.85	1.71	1.55	1.66	1.54	1.39	1.57	1.46	1.32	2.16	2.01	1.81	[illegible]	1.91	1.72	1.81	[illegible]	1.64	[illegible]	[illegible]	1.46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Kentucky No. 1	a12
a7	Nov. 3	1.33	Missouri No. 2	340.5	300.0	255.0	384.5	339.0	283.0	[illegible]	11,882	14,280	140.0	8,820	11,560	19,300	55.7	63.0	75.7	50.2	56.8	68.2	1.87	1.65	1.37	1.71	1.51	1.28	1.50	1.40	1.17	1.48	1.31	1.09	2.07	1.83	[illegible]	.91	1.71	1.43	1.70	[illegible]	1.40	1.65	1.45	[illegible]	[illegible]	30	[illegible]	[illegible]	[illegible]	[illegible]	Missouri No. 2	a7
a5	Oct. 24-25	22.93	Montana No. 1	450.5	401.5	355.8	500.8	440.1	395.0	10,575	11,914	13,580	160.8	6,580	11,340	19,540	36.2	40.9	46.5	32.0	36.8	41.9	2.39	2.12	1.86	2.29	2.03	1.78	2.03	1.80	1.58	1.95	1.72	1.52	2.66	2.36	2.07	2.51	2.25	1.98	2.26	[illegible]	1.70	2.16	1.91	1.68	9.04	[illegible]	[illegible]	8.00	1.81	56.10	Montana No. 1	a5
a10	Nov. 14-15	30.00	North Dakota No. 2	400.0	278.0	249.0	510.0	408.0	275.8	6,802	11,255	12,000	188.5	7,830	[illegible]	11,550	25.2	41.5	46.4	22.7	37.5	41.9	3.67	2.22	1.99	3.42	2.07	1.86	3.13	1.89	1.69	2.91	1.76	1.58	4.07	2.46	2.20	3.80	2.29	2.05	[illegible]	2.09	1.88	3.21	1.95	1.71	8.00	[illegible]	20.80	14.31	1.85	51.09	North Dakota No. 2	a10
a11	Nov. 21-22	21.07	Texas No. 1	500.0	303.0	332.0	600.0	430.5	371.1	[illegible]	10,928	12,935	180.7	[illegible]	12,230	10,800	28.4	42.7	50.6	25.5	38.2	45.3	3.10	2.10	1.78	2.98	1.99	1.68	2.08	1.79	1.51	2.54	1.69	1.43	3.53	2.35	[illegible]	3.34	2.22	1.88	3.00	2.20	1.69	2.83	1.88	1.60	11.10	[illegible]	[illegible]	10.51	[illegible]	[illegible]	Texas No. 1	a11
18	Dec. 21-22	10.33	Texas No. 2	458.0	310.3	270.2	510.5	344.4	300.6	[illegible]	11,086	12,450	156.2	8,060	10,570	16,000	34.2	51.0	57.6	30.8	46.4	52.2	2.47	1.64	1.46	2.33	1.54	1.37	2.10	1.39	1.24	1.98	1.31	1.17	2.71	1.82	1.62	[illegible]	1.71	[illegible]	[illegible]	1.60	1.38	[illegible]	1.10	[illegible]	9.00	10	18.29	[illegible]	4.81	[illegible]	Texas No. 2	18
3	Oct. 17-18	24.00	West Virginia No. 1	287.5	283.0	265.5	320.0	315.0	296.1	14,160	14,390	15,350	111.4	9,260	14,130	18,150	63.2	64.1	68.4	56.6	57.5	61.3	1.51	1.49	1.40	1.43	1.41	1.33	1.29	1.27	1.19	1.22	1.20	1.13	1.69	1.66	1.56	1.60	1.57	1.48	1.44	1.41	1.33	1.36	1.34	1.26	[illegible]	10	11.34	2.81	1.50	[illegible]	West Virginia No. 1	3
4	Oct. 20	9.00	West Virginia No. 1	233.0	220.0	208.0	262.8	258.2	233.5	14,048	14,202	15,400	113.2	11,010	11,320	18,500	79.6	81.2	89.2	70.6	71.9	79.2	1.23	1.21	1.10	1.17	1.15	1.04	1.05	1.03	.94	.99	.98	.91	[illegible]	1.36	1.24	1.32	1.29	[illegible]	1.18	1.16	1.05	1.12	1.10	1.00	10.10	21	[illegible]	11.18	1.71	[illegible]	West Virginia No. 1	4
17	Dec. 19	6.33	West Virginia No. 9	300.0	292.0	274.0	328.0	320.1	301.4	11,195	14,580	15,500	151.0	8,150	10,060	15,770	52.0	54.0	57.4	48.0	49.3	52.3	1.60	1.56	1.47	1.49	1.46	1.37	1.36	[illegible]	1.25	1.27	1.24	1.16	1.76	1.71	1.61	1.64	1.59	1.50	1.49	1.46	1.37	[illegible]	[illegible]	[illegible]	10.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	West Virginia No. 9	17
a8	Nov. 7-8	30.00	West Virginia No. 12	270.0	260.1	218.7	301.0	300.5	280.0	14,611	14,825	15,800	142.5	10,140	11,500	18,957	70.2	71.2	76.2	62.1	63.2	67.5	1.11	1.30	1.30	1.35	1.33	1.24	1.20	1.18	1.11	1.15	1.13	1.06	1.59	1.57	[illegible]	1.53	1.50	1.40	1.35	1.34	1.25	1.30	1.28	1.20	[illegible]	[illegible]	[illegible]	[illegible]	1.01	[illegible]	West Virginia No. 12	a8
16	Dec. 16-17	30.00	Wyoming No. 2	403.3	365.5	281.0	450.8	416.5	324.1	9,650	10,656	13,820	151.0	6,168	9,516	14,923	37.0	40.0	[illegible]	32.5	35.8	46.5	2.18	1.98	1.52	2.00	1.82	1.40	1.86	1.68	1.30	1.70	1.54	1.19	2.49	2.25	1.71	2.28	2.07	1.60	2.11	[illegible]	1.48	1.91	1.70	1.36	10.91	30	[illegible]	10.70	5.62	57.43	Wyoming No. 2	16

a Gas producer hopper leaked during these tests.

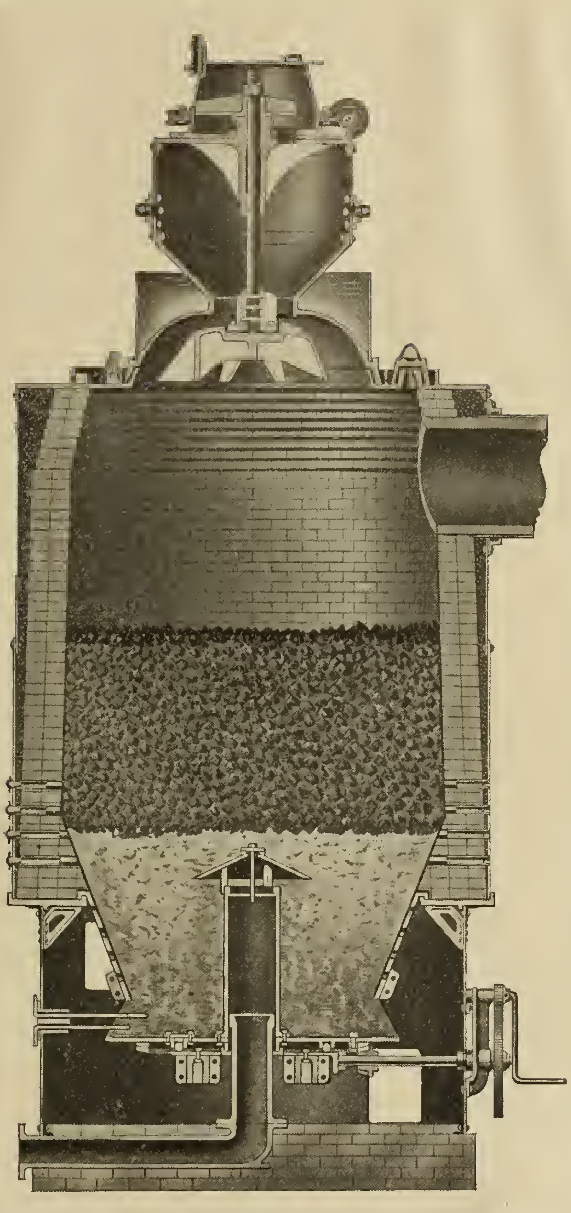
While we are particularly interested in what the producer can do with Illinois coals, yet it is interesting to look over this table to see what results were obtained with other soft coals. It will be noticed that a B.H.P. per hour was obtained in every case with a very small amount of coal as compared with the coal consumed per B.H.P. per hour in the average steam plant. The possibilites of a very high degree of economy are shown in the test of West Virginia No. 4 which developed a B.H.P. hour on .99 lbs. of coal.

This test would lead us to believe that the Wood producer would satisfy the conditions for this plant.

(b) THE WOOD PRODUCER.- The Wood Producer in itself is a very simple affair as can be seen from the accompanying cut. It consists essentially of a main cylindrical chamber of fire brick enclosed by an iron shell, an automatic feed device, a revolving ash table and a hooded tube for carrying the blast of steam and air up into the producer.

The ash table as is shown can be revolved by turning the crank which projects from near the base of the producer. This table is made larger in diameter than the bottom of the bosh and is placed several inches below it, so that the ash will be readily discharged on turning the table. The bed of ash is kept about 3-1/2 feet deep on the revolving table.

The hooded pipe which carries the blast of steam and air passes up into the ash to a point within about 6" of the coal. The hood causes the steam and air to be distributed radially and uniformly to the fire above. The top of this pipe should at no



A

GAS PRODUCER WITH ROTATIVE ASH TABLE AND BILDT CONTINUOUS AUTOMATIC FEED.

time be allowed to project above the ashes into the fire. This dividing line between ash and fire can be watched through peep holes provided for the purpose. (See cut.)

The gas passes out of the producer through the large pipe near the top.

The "Bildt Automatic Feed" which surmounts the producer consists of a receiving hopper below which is a storage magazine of considerable size, and through this magazine passes a small vertical shaft with the distributor plate fastened to its end. The shield or hood which encloses the distributor plate and also forms the base of the magazine, is cooled by a water jacket as shown. The water jacket serves the further purpose of sealing the joint between the producer and the hood thus preventing leakage of gas at this point. There are peep holes in the side of the magazine for inspection,or for the insertion of rods. The receiving hopper above the magazine is keyed to the distributor plate shaft and is rotated by the worm and worm wheel as shown. The rate of coal discharge is regulated by a variable speed of distributor plate and by raising or lowering the distributor plate, by means of the nut at the top of the shaft. The distributor plate is so constructed as to give a spiral distribution of the coal over the entire surface above the fire. In operation the magazine can be filled without serious loss of gas if it is done while there is still some coal left in the bottom of the magazine to prevent the escape of any large volume of gas.

(c) PURIFIERS AND OTHER AUXILIARY APPARATUS.- The gas leaves the producer through a large pipe near the top of the producer and

enters the economizer. The economizer consists merely of a cylindrical iron shell inside of which are several large pipes. The gas passes through these pipes and imparts some of its heat to the air filled outer chamber. This hot air is used for the blast in the producer and is sucked out of the economizer, by means of a steam jet blower, and up onto the producer. The steam for jet blower is furnished by a small steam boiler.

The gas leaves the economizer and enters the bottom of the coke scrubber. The scrubber is filled with coke and is constantly flushed by a jet of water which is sprayed in from the top . The gas deposits here most of its dirt and solid matter except that most of the tar remains.

From the scrubber the gas passes through the tar extractor. The mechanical construction of this piece of apparatus can not be given as it is carefully guarded by the makers. However, in external appearance it resembles a centrifugal pump and works on the same principal as a cream separator. That is the gas is revolved at a high rate of speed and the tar and heavier foreign matter is thrown to the outer casing of the machine where it runs down to the bottom and is drained off through a small pipe.

The gas next passes through a purifier which is a rectangular iron box containing several layers of oxidized iron filings and shavings. This extracts the sulphur, moisture and remaining impurities and completes the purification of the gas.

The gas enters the holder after leaving the purifier. The holder is under pressure and thegas flows from it to the engines as is required.

VI.

DESCRIPTION OF PLANT.

(a) Referring to Plate I it will be seen that the building consists of two parts, a producer room in the west end and an engine room in the east end of the building. On the south side are the Big Four tracks with plenty of room to run in a switch track, over which coal can be brought to the producer room. To the north of the building, between it and the road, is the gas holder and the cooling tower.

(b) PRODUCER ROOM.- In Plate II will be found a plan of the producer room. Along the south side of this room is a large coal bin. The coal is brought to the bin over the switch track, already mentioned, and is elevated by a conveyor to the charging car which in turn carries it to the producers as needed. North of the coal bin and along the west wall is located the No. 8 producer and in line with it, in the order named,is the economizer, the scrubber, the tar extractor and the purifier. There are two other lines of producer apparatus, differing from that just described only in that the producers are number sevens and not number eights. Along the east wall of the room is a fourth row of apparatus consisting of an economizing chamber to heat the air for the boilers, a vertical boiler, a well and a water supply tank, a compressed air holder and a gas meter. The boiler is of the vertical type and is about 16 horse power capacity. The feed water for this boiler is taken from the gas engine jackets, thus saving considerable heat which would have been lost in the engine exhaust. More of the heat from the exhaust gases is saved in the

economizing chamber where the air for the boiler is heated.

The supply tank is 8 feet in diameter by 8 feet high and is supported by a steel tower, twenty feet high. The tank is fed by a 4" centrifugal pump, electrically driven, and capable of supplying all the water needed for the entire plant. The tank will also furnish pressure for the entire system.

All the waste water from scrubbers and other apparatus is led away through channels in the floor.

Along the walls are water pipes from which leads are carried down to about four feet from the floor, so that hose can be attached for use in cleaning or in case of fire?

In one corner of the room are toilet and locker rooms for the use of the workmen.

Plate III which is a end view of the producer room shows the arrangement of the apparatus just described and gives an idea of the relative size of producers and other apparatus.

(c) ENGINE ROOM.- Plate IV gaves a plan of the engine room and locates the engines, pumps, air compressor, etc. The engines are set in a row ten feet from the south wall and have aisles ten feet wide between them. At the end of the 100 H.P. engine is a 5 H.P. compressor to supply air for starting the engines. The compressor is connected to an air pressure storage tank which is in the producer room. At the end of each of the 200 H.P. engines is a small centrifugal pump used for circulating water through the engine jackets, out to the cooling tower and back to the engine jackets.

Office, stock, repair, instrument, locker, and toilet rooms

are all located along the north side of the room.

In order to facilitate the handling of heavy parts of engine and dynamos, a ten ton traveling crane spans this room.

(d) PRINCIPALS DIMENSIONS AND DATA OF AUXILIARY GAS PRODUCER POWER PLANT FOR THE UNIVERSITY OF ILLINOIS.-

Building

Ground area in square feet	10760.
Dimensions in feet	(av.) 163 x 66.

Producer Room.

Ground area	4820.
Dimensions	73 x 66.
Height- main bay	(av.) 32.
" - side bay	23.

Engine Room.

Ground area	5940.
Dimensions	66 x 90.
Height- at eaves	20.
" - at ridge	30.

Producers

Type	R. D. Wood & Co..
Number- one No. 8- two No. 7-	3.
Rated- No. 8	350 H. P.
" - No. 7	200 H. P.
Total H. P.	750.
Inside Diameter- No. 8	8'.
External Diameter- No. 8	10'.
Inside Diameter- No. 7	7'.

External Diameter- No. 7	8' - 6".
Height of No. 8- including Bildt Feed	24'.
" " No. 7- " " "	23'.

Economizers.

Number wanted	3.
External Diameter	3'.
Height	16'.

Scrubbers.

Number wanted	3.
External Diameter	8'.
Height	20'.

Purifiers.

Number wanted	3.
Area- 8' x 8'	64.
Height	3'.

Tar Extractors.

Number wanted	3.
Diameter- approximately	4'.

Boiler.

Type	Vertical.
Diameter	8'.
Height	20'.

Water Supply Tank.

Number wanted	1.
External Diameter	8'.
Height	8'.

Gas Meter.

Type	Westinghouse.
Size	18'.

Pumps.

Feed Water Pump- Type	Centrifugal.
Size	4".
Capacity (gallons per minute)	392.
Circulating pumps-wanted	1.
Size	3".
Capacity (gallons per minute)	300.

Compressor.

Type	Westinghouse.
Rated	5 H. P.

Compressed Air Tank.

External Diameter	3'.
Height	8'.
Pressure-(pounds per sq. in.)	200.

Generators.

Type	A.C.- Direct Connected- Westinghouse.
Capacity (kilowatts)	525.
Voltage	1000.

Engines.

Number wanted- 3, 200 H.P.- 1, 100 H.P.	4.
Type	Westinghouse Vertical, Single Acting, Three Cylinder, Direct Connected .
Length of 200 H.P. Engine and Generator	22'- 9".
Width of 200 H. P. " " "	8'- 8".

Height of 200 H.P. Engine and Generator	12'-10".
Length of 100 H.P. " " "	16'- 9".
Width of 100 H.P. " " "	6'- 9".
Height of 100 H.P. " " "	10'- 5".

Crane.

Capacity	10 tons.
Span	47 feet.

Stack.

Type	Steel.
Height- (above floor line)	45'.
Inside Diameter	1'.

Coal Handling Machinery.

Type	Hunt Conveyor.
Capacity	5 ton per hour.

Piping.

Gas Main to Holder	24".
Leads to Main	18".
Exhaust Gas Main	24".
Main to Engine	15".
Compressed Air Lead	2".
Jacket Water Main	4".
Feed Pipe- Water	3".
Lead Pipe to Jacket and Pump	2".

VIII.

SPECIFICATIONS.

Contents

I.- Generators and Engines to furnish 600 H.P. at switch board.

II.- Producers and auxiliary apparatus to furnish gas to 700 H.P. of engines.

III.- Vertical fire tube boiler of 16 H.P. capacity.

IV.- Economizing chamber for boiler.

V.- Water supply tank.

VI.- Coal handling machinery.

VII.- Pumps.

VIII.- Piping for steam, water and exhaust gases.

IX.- Air Compressor.

X.- Crane for engine room.

XI.- Cooling tower.

XII.- Gas holder.

SPECIFICATIONS FOR AN
AUXILIARY GAS PRODUCER POWER PLANT
FOR THE UNIVERSITY OF ILLINOIS.

Specifications for material and labor required in the construction and installation of an Auxiliary Gas Producer Power Plant for the University of Illinois, Urbana, Ill.

Prepared by C. E. Skelley and A. B. Shipman, consulting engineers, 506 Springfield Ave., Champaign, Ill.

GENERAL DESCRIPTION.

Location.- The work herein specified is for the University of Illinois and the plant is situated in Urbana, one half mile north of the University on the line of the C.C.C. & St.L. R.R.

Return of Plans.- All plans and specifications are to be returned to this office, 506 Springfield Ave., Champaign, Ill., as they are the property of the University.

Drawings.- Plates No. I, II, III, IV, V give general arrangement of producers, coal bunkers, coal handling machinery, piping, boiler, purifying apparatus, engines and miscellaneous fixtures.

Supervision of Work and Materials.- The consulting engineers will have general supervision for the University, over all materials and work and have the power to reject any defective material or work.

Omissions.- Any work drawn and not specified or specified

and not drawn or mentioned, necessary to the satisfactory completion of the work is to be done without extra charge.

Damage by Accidents.- The contractor shall put up and maintain barriers andred lights such as will prevent accidents. He will be held liable for all damages resulting from his neglect or that of his agents or employees.

PART I.

Specifications for 700 H.P. Engines and Generators.

The engines are to be of the Westinghouse, three cylinder, vertical type of special design for the use of producer gas and they are to be direct connected to the generators. There shall be one (1) 100 H.P. engine connected to a 75 K.W. generator, and three (3) 200 H.P. engines, each connected to a 150 K.W. generator.

Generators are to deliver a total of 525 K.W. at a terminal pressure of 1000 volts and should be capable of standing at least a 25% overload. Generators shall be wired complete to a switch board and work must be guaranteed safe and of sufficient capacity.

Engines and generators are to be delivered and set in plant on first class concrete foundations, located as shown in drawings.

All piping and connections from gas holder to engines shall be furnished by contractor. This piping shall be tested up to 100 lbs. pressure in the presence of the engineers.

A gas meter of sufficient capacity and of approved make (Westinghouse will be approved) shall be furnished by contractor.

PART II.

Specifications for Producers and Auxiliary Apparatus.

Producers are to be of the R. D. Wood make; one (1) No. 8 and two (2) No. 7. To accompany these producers are three (3) economizers, three (3) scrubbers, three (3) tar extractors and three (3) purifiers of sufficient capacity to deliver pure gas to the holder when producers are run at normal load. Each producer shall be fitted up with a "Bildt Automatic Feed" device and a revolving ash table.

These producers and auxiliary apparatus shall be delivered and erected upon first class concrete foundations in the producer room; location of foundations shown in drawings.

All the necessary piping, connections, valves, etc. used from producer to gas holder and for drips shall be included in this bid.

The system shall be tested for leaks to 100 lbs. pressure in the presence of the engineers.

There are to be three (3) ten and three (3) seven horse power induction motors; three to be direct connected to the tar extractors and three to be located on charging floor and to be belt connected to the automatic feeds on the producers.

The necessary transformer to step down the voltage for use in these motors shall be included in the bid.

PART III.

Specifications for 16 H.P. Vertical, Fire Tube Boiler.

There is to be one (1) 16 H.P., vertical, fire tube boiler. The boiler is to be supplied with all the usual fittings and fixtures of proper size and strength. The boiler is to be delivered and erected in producer room, on a suitable foundation to be approved by the engineers.

This bid shall also include one (1) steel smoke stack, 1 ft. in diameter by 45 ft. high.

PART IV.

Specifications for Economizing Chamber.

There shall be one economizing chamber for heating air for boiler, having a base 8' x 6' and 6' high.

Bidder must submit plans and drawings to engineers for approval.

PART V.

Specifications for Water Supply Tank.

There shall be one (1) water supply tank, 8 ft. in diameter by 8ft. high. It shall be mounted on a steel tower, 20 ft. high and be of ample strength to support tank filled with water.
Tank shall be provided with such connections as are shown on drawing. Tank and tower shall be delivered and set in place in producer room.

PART VI.

Specifications for Coal Handling Machinery.

There shall be a coal hoist capable of elevating 5 tons of coal per hour from coal bin to charging car. (Hunt hoist will be approved.) The hoist is to be driven by a direct connected induction motor at top of shaft. This apparatus shall be delivered and erected in producer room.

PART VII.

Specifications for Centrifugal Pumps.

There shall be one (1) centrifugal pump, (R. D. Wood & Co. No. 4), capacity 392 gallons per minute, and one (1) centrifugal pump (R. D. Wood & Co. No. 3), having a capacity of 225 gallons per minute. Pump No. 4 is to be driven by a 10 H.P. induction motor, direct connected. Pump No. 3 is to be driven by a 6 H. P. induction motor direct connected.

Pumps and motors are to be delivered and erected on suitable foundations to be approved by the engineers.

PART VIII.

Specifications for Piping for Steam, Water and Exhaust Gases.

The contractor is to furnish all piping, valves, tees, crosses, and ells for steam from point K at producer inlet to and including steam valve on boiler; also all piping, etc., from air compressor to air tank and from air tank to inlet valve on engines;

also all piping, valves, fittings, etc. for water conveyance from supply tank to engines, boilers, toilet rooms, cooling tower, etc. according to drawings. The contractor shall also furnish piping, valves, and connections for exhaust gases to economizer and from there to the outside atmosphere.

All air piping is to be extra heavy and is to be tested by water pressure up to 300 lbs. All water piping is to be tested up to 100 lbs. water pressure. All steam piping is to be tested up to 75 lbs. hydraulic pressure for leaks.

All changes made necessary by any changes of plans for piping shall be made without extra charges, providing it does not involve the use of any extra material. The contractor shall furnish any extra labor or material at a price agreed upon by both parties and stated in writing before work is begun.

Sizes and lengths of all above mentioned piping are shown on drawings.

PART IX.

Specifications for Air Compressor.

The air compressors shall furnish 5 cu. ft. of air per minute at 200 lbs. gauge pressure and shall be gas driven. The compressor and engine is to be delivered and erected, with necessary gas piping, in engine room.

Contractor shall also furnish and erect a compressed air tank 3 ft. in diameter by 8 ft. high.

PART X.

Specifications for Crane for Engine Room.

The crane shall be of the traveling type of 10 ton capacity, with span of 47 ft. from center of track, to center of track. The necessary motors for driving crane shall be furnished with the crane. The track shall be furnished and installed by the contractor.

PART XI.

Specifications for Cooling Tower.

The cooling tower shall be 14 ft. high having floors every 2 ft. The top floor shall be 24 ft. long by 16 ft. wide. The lower floor shall be 36 ft. long by 24 ft. wide. These floors are to be made of one inch lumber. The tower is to be set in a concrete basin, 40 ft. long by 28 ft. wide by 1 ft. deep.

PART XII.

Specifications for Gas Holder.

There shall be one (1) gas holder, 30 ft. in diameter by 20 ft. high. This holder shall be delivered and erected at plant on such foundation as is necessary.

CALCULATIONS AND ASSUMPTIONS.

The following are the calculations upon which the choice of sizes of apparatus was made.

Engines and Generators.

Required at switch board	600 H.P.
Assumed efficiency of engines and generators	85%.
Required in engines,.	600 ÷ .85 = 700 H.P.

Three 200 H.P. and one 100 H.P. engines, a total of 700 H.P.

Producers.- From advice of the R. D. Wood & Co. and data at hand two No. 7 and one No. 8 producer will supply necessary gas for engines. Sizes of purifying apparatus are such as usually supplied with the producers. Gas holder is of size usually installed with given capacity of producers.

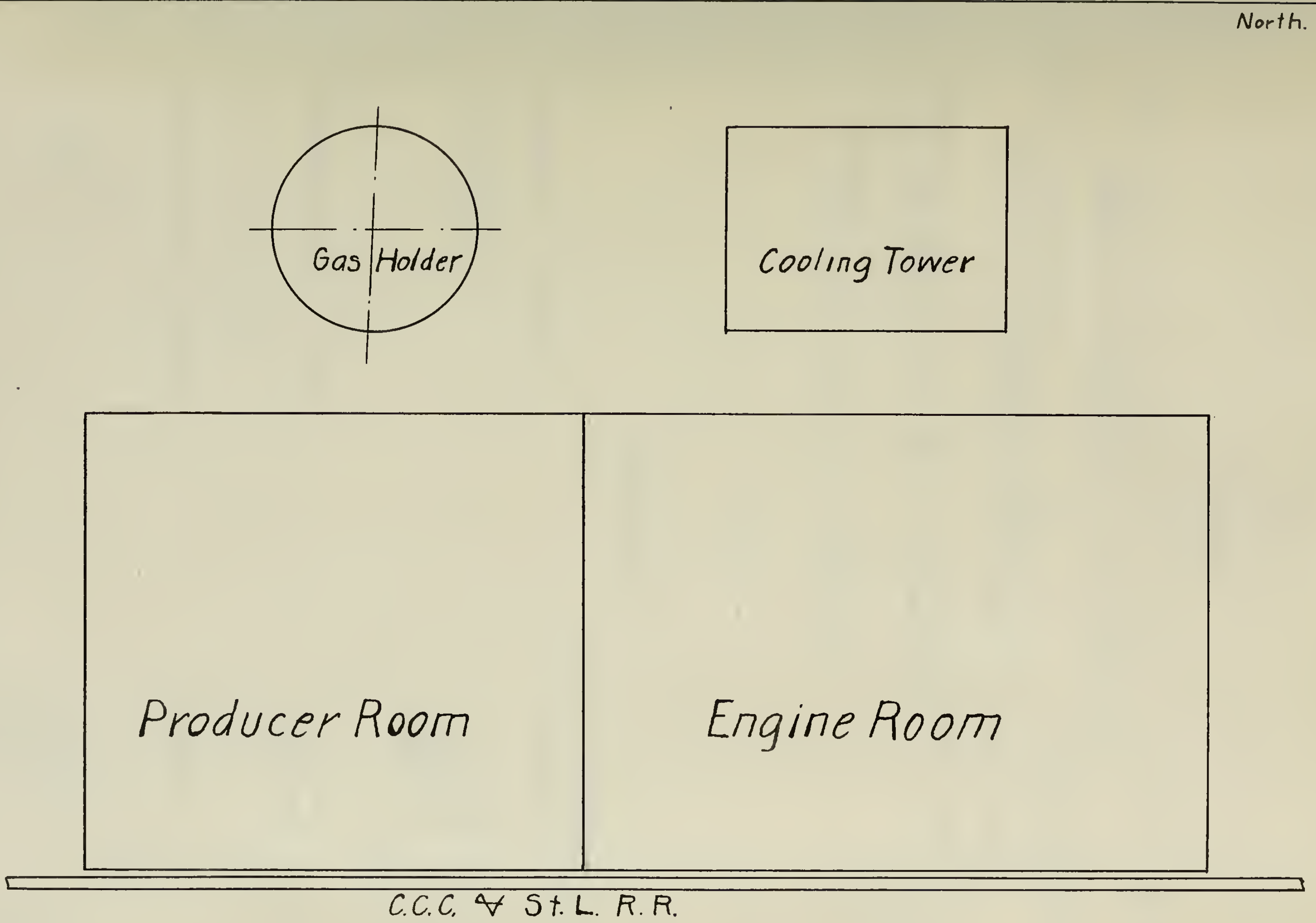
Water for Plant.

Required to wash 1000 cu. ft. of gas	5 gals.
Gas required per hr. by engines	84000 cu. ft.
Water to scrub total gas per hr.	420 gals.
Per cent of heat taken up by jacket water of engines	40%.
Degrees change in temp. of cooling water	50.
Total heat required per hour in gas	8,400,000 B.T.U.
Jacket water per hour	8050 gals.
Total water for scrubbing and cooling per min.	141 gals.

In order that the pump shall furnish all water needed at all times such as may be needed for scrubbing gas, cooling engine cylinders and all other purposes about plant, also for future extension of plant andshut down of pump, it was decided to install

a pump capable of furnishing about three times the amount mentioned above. R. D. Wood & Co.'s catalogue give 392 gals. per minute for a 4" pump. This will be used.

In order not to overwork the well, the jacket water is cooled and requires circulating pumps. Of this cooling water there is about 135 gallons per minute. After consulting table, catalogue 1, No. 3 was chosen.



PLAN OF PLANT

I

C.E.S.

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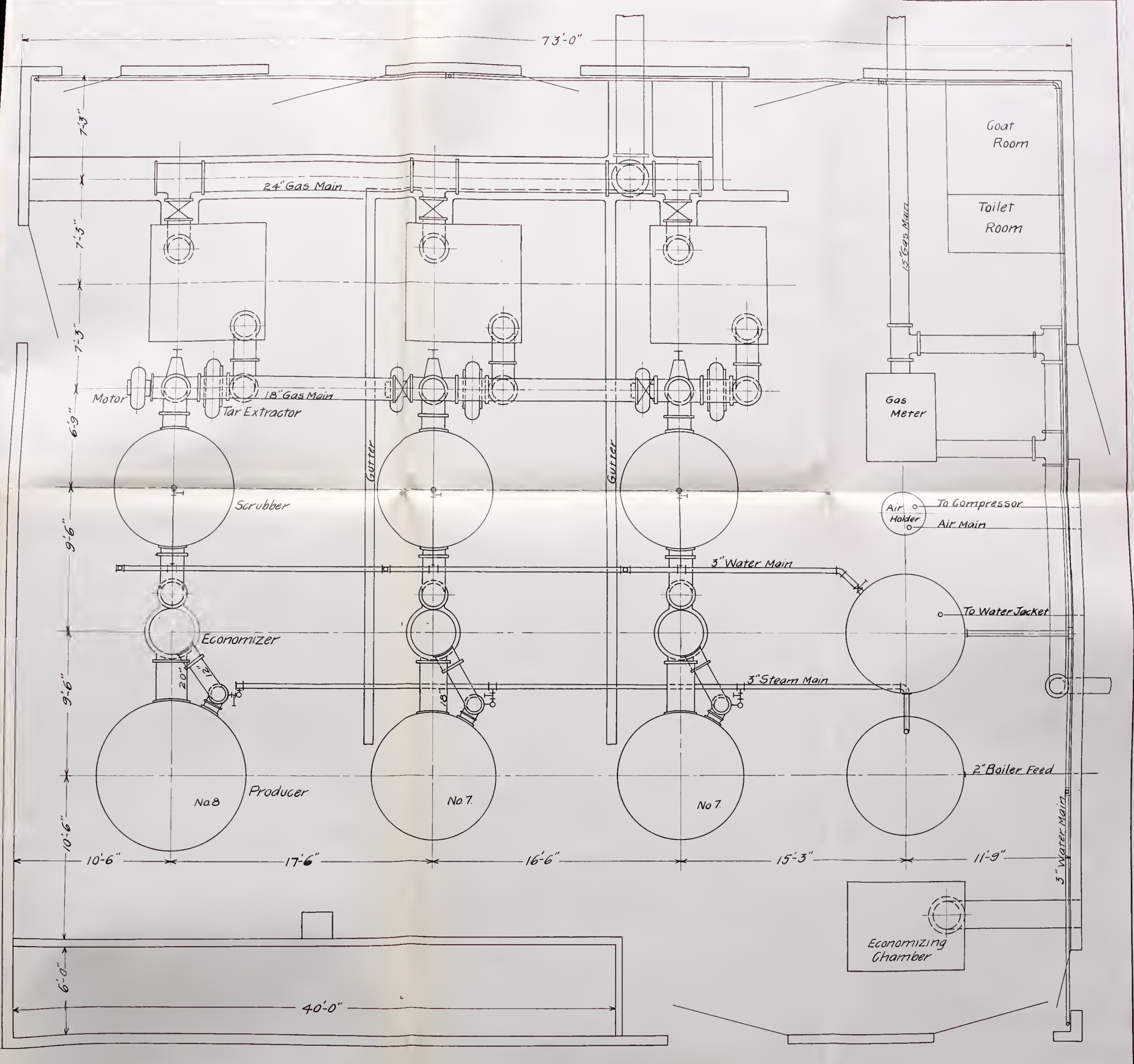
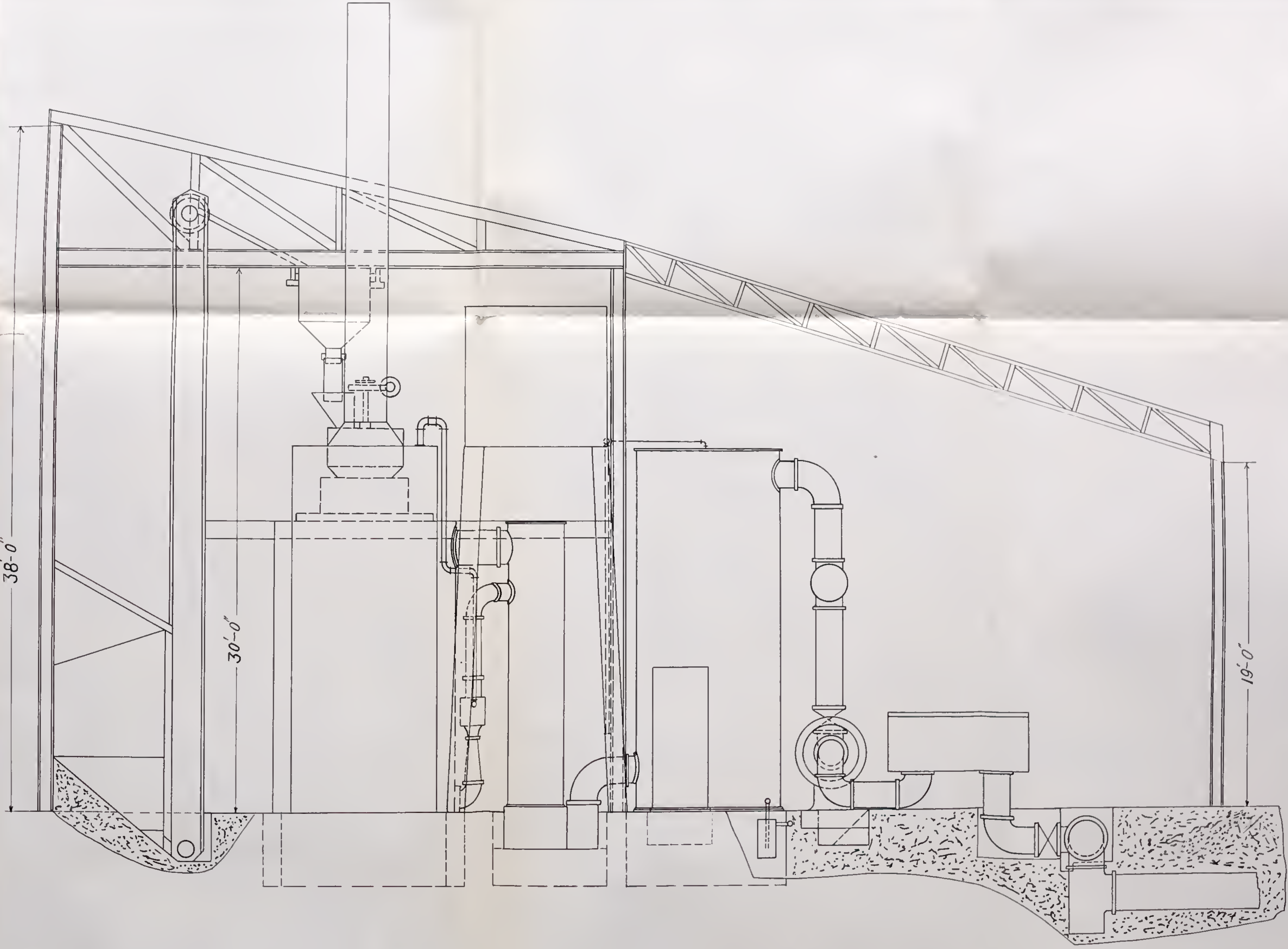


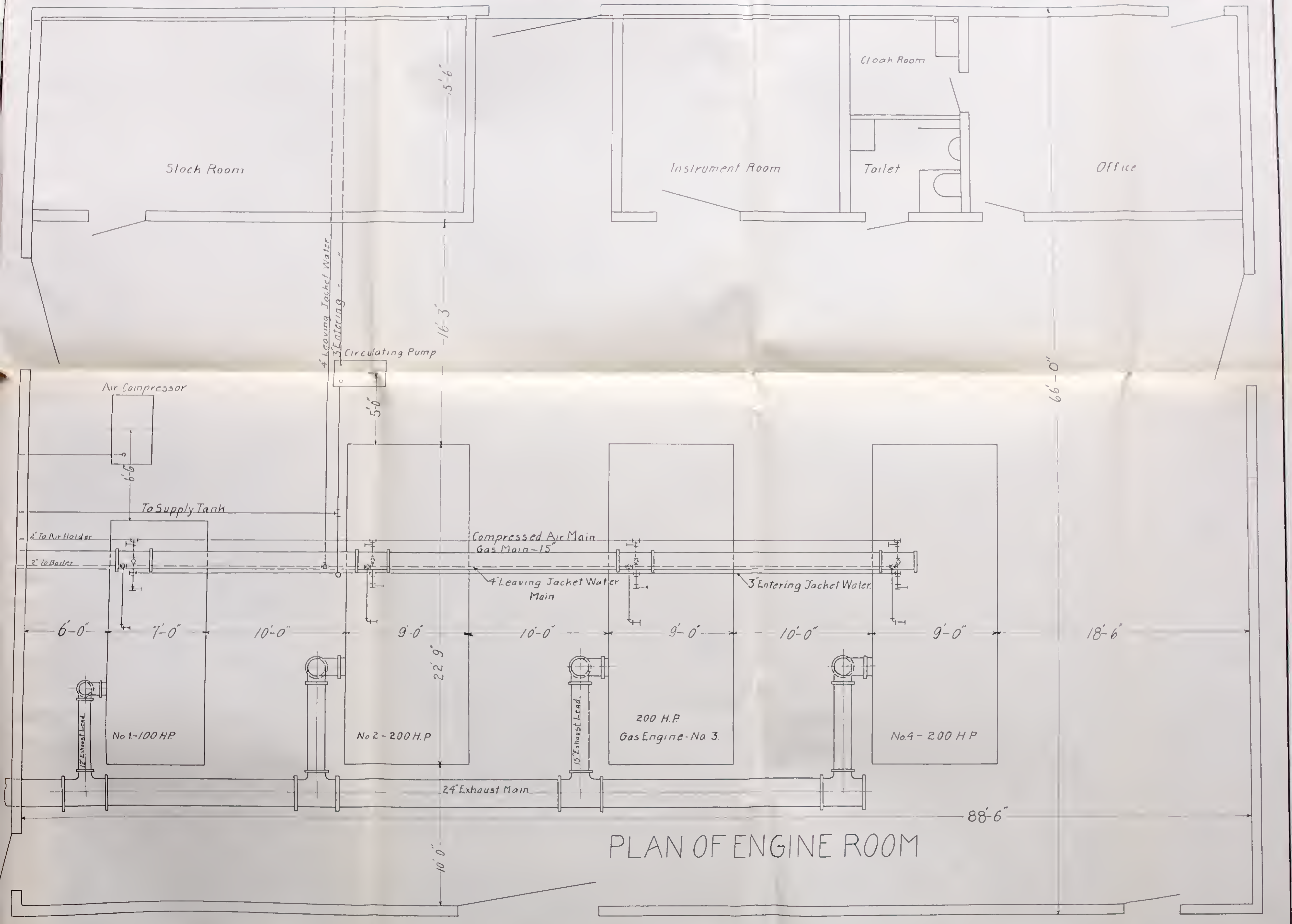
PLAN OF PRODUCER ROOM

II



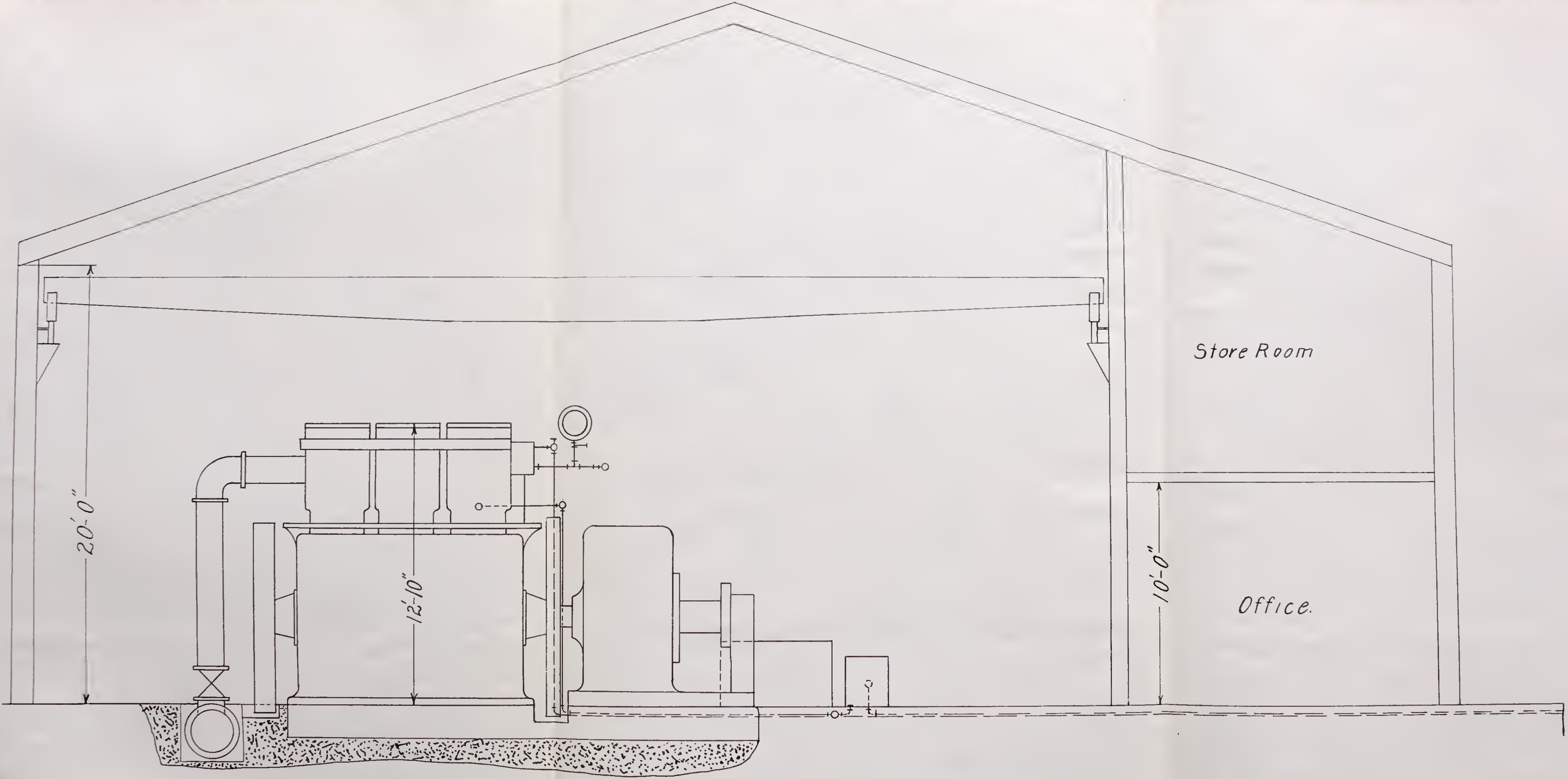
ELEVATION OF PRODUER ROOM

III.



PLAN OF ENGINE ROOM

IV



ELEVATION OF ENGINE ROOM

V.

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